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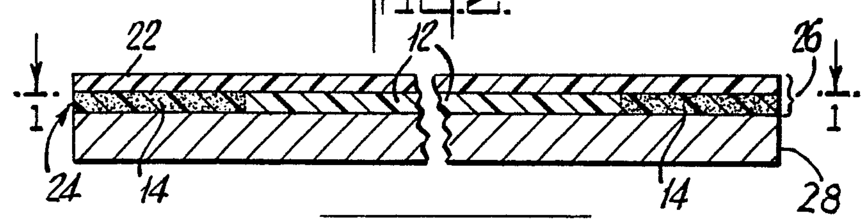
(54) **Microwave interactive film, microwave interactive laminate and method for producing microwave interactive laminate.**

(57) In a microwave cooking heater element comprising a heat stable plastic film coated with a very thin layer of microwave interactive material to form a microwave interactive film, the improvement is provided which comprises the presence in said very thin layer of an inactivated area wherein the capability of said inactivated area to generate heat in response to microwave energy has been reduced by treatment with an inactivating chemical followed by drying. Furthermore, a microwave interactive laminate is provided which has been treated with an inactivating chemical, comprising said microwave interactive film and a substrate layer bonded to said microwave interactive film, wherein said very thin layer of microwave interactive material is between said heat stable plastic film and said substrate layer as well as a method for making such microwave interactive laminate.

Fig.2.



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MICROWAVE INTERACTIVE FILM, MICROWAVE INTERACTIVE LAMINATE AND METHOD FOR PRODUCING MICROWAVE INTERACTIVE LAMINATE

The present invention relates to a microwave interactive film as a microwave cooking heater element comprising a heat stable plastic film coated with a very thin layer of microwave interactive material to form said microwave interactive film and to a method for chemically treating a microwave interactive material to reduce or eliminate the capacity of the microwave interactive material to generate heat in response to microwave energy. The present invention also relates to chemically modified microwave interactive laminates which include a chemically treated microwave interactive layer and to a container for the storage and microwave cooking of food having such laminates.

A characteristic of microwave cooking is that the exterior of foods cooked in a microwave oven, such as breads, do not have a brown or crisp texture desired by consumers.

One technique developed to brown or crisp the exterior of foods during microwave cooking has been the incorporation of a lossy or microwave interactive material into packages which contain foods. When subjected to microwave energy, the microwave interactive material generates heat which browns or crisps the surface of food.

A film with a microwave interactive layer deposited on one side is a microwave interactive film. Microwave interactive films suitable for use in the present invention are commercially available and are well known to those skilled in the art.

A microwave interactive laminate may be formed by bonding an interactive film to a substrate support structure preferably with the microwave interactive layer sandwiched between the film and the substrate. The laminate may be subsequently cut into a shape that approximates the shape of a particular food product or the size of a particular package.

Commercially, microwave interactive laminate can be most conveniently cut into rectangles for use in packages. When the food product which is to be heated is circular, triangular or some other shape which does not conform to a rectangle,not all of the heat-generating area of the microwave interactive laminate will be covered by the food product. The uncovered or exposed area of conventional microwave interactive laminate can produce excessive heat which can scorch the food or the container and reduce the efficiency of the mircowave interactive laminate.

With conventional microwave interactive laminates, the heat-generating areas may overlap when a package is assembled resulting in excessive heat generation at the areas of overlap, which can scorch the food or the package as well.

It is an object of this invention to so define heating area of the laminate as to avoid overlapping of heat-generating areas in an assembled package and sto provide heat generating areas of the laminate in those regions best suited to heating the contents of the container.

According to the present invention a microwave interactive film is provided which has been treated with an inactivating chemical, comprising a heat stable plastic film, and a very thin layer of microwave interactive material deposited onto one side of the film, the microwave interactive film having a heating area and an inactivated area treated with an inactivating chemical. The inactivating chemical reduces the ability of the treated or inactivated area to generate heat in response to microwave energy.

A further embodiment of the present invention is a microwave interactive laminate, comprising,

(a) a microwave interactive film as defined above, having a heating area and an inactivated area wherein the capability of the inactivated area to generate heat in response to microwave energy has been reduced by said inactivating chemical; and,

(b) a substrate layer bonded to said microwave interactive film to form a microwave interactive laminate, wherein the microwave interactive material is between the film layer and the substrate layer.

A further embodiment of the present invention is a method of making a microwave interactive laminate, comprising,

(a) depositing a very thin layer of microwave interactive material on one side of said heat stable plastic film,

(b) treating a selected area of said very thin layer with an inactivating chemical in an amount sufficient to convert the selected area into an inactivated area with reduced capability of generating heat in response to microwave energy; and

(c) bonding the microwave interactive film treated in accordance with step (b) to a substrate layer to place the microwave interactive material between the film and the substrate support layer.

Figure 1 is a sectional view along the plane 2-2 of Figure 2 of a microwave interactive laminate in accordance with the present invention illustrating heating and inactivated areas.

Figure 2 is a cross-sectional view along plane 1-1 of figure 1, distorted in the vertical dimension to show detail of a microwave interactive laminate as illustrated in Figure 1 along line 1-1.

Figure 3 is a schematic representation of apparatus which may be used to produce a microwave interactive laminate in accordance with the present invention.

One embodiment of the present invention, illustrated with reference to Figure 1, is a microwave interactive laminate 10 having an active heating area 12 and an inactivated area 14.

A selected area of a microwave interactive material is chemically modified, corresponding to inactivated area 14, as explained in detail hereinafter, thereby reducing or eliminating its ability to generate heat in response to microwave energy without impairment of the untreated heating area 12 of the microwave interactive material.

In the embodiment of the invention illustrated in Figure 1, the unmodified heating area 12 is circular to approximate the shape of a circular food product, such as a pizza. In use, the food product normally will cover heating area 12 when the food is placed in a package provided with the microwave interactive film or laminate 10. The area of the microwave interactive layer corresponding to heating area 12 will generate heat in response to microwave energy, preferably an amount sufficient to heat to brown or crisp the surface of food product placed in or on the package.

The location of the heating area in a package or container may be on any surface of the package or container where heat for browning or crisping the food is desired. The heating area may be therefore, at the bottom interior surface, on the top interior surface, on the vertical interior surfaces or top exterior surface of a container, depending on where the heat for browning or crisping food is desired and the kind of container involved.

Figure 2 illustrates the layers making up microwave interactive laminate 10. It will be understood that the dimensions of the layers illustrated in Figure 2 are exaggerated for purposes of illustration and are not necessarily in correct proportion to one other.

With reference to Figure 2, film 22 is a heat tolerant and heat stable material. Immediately adjacent film 22 is microwave interactive layer 24 which is a thin layer of material capable of generating heat in response to microwave energy. In the embodiment illustrated in Figure 2, a selected area of the microwave interactive layer 24 hs been chemically treated to form inactivated area 14. By converting the selected area 14 into an inactivated area 14 by chemical treatment in accordance with the present invention, the shape and heating characteristics of heating area 12 may be precisely controlled. The microwave interactive layer 24 is usually vacuum vapor deposited onto one side of film 22 by means known in the art to form microwave interactive film 26 consisting of film 22 and layer 24.

Other known methods for depositing a microwave interactive layer 24 onto a film layer 22, for example by sputtering or printing, may be used. As illustrated in Figure 2, a selected area of the microwave interactive layer 24 is inactivated by treatment with an inactivating chemical without removing the microwave interactive layer 24. After the treating step, the microwave interactive film 26, is bonded to substrate layer 28 with an appropriate adhesive. Substrate layer 28 provides laminate 10 with structural rigidity and a fixed shape which conforms to the shape of a package into which the microwave interactive laminate 10 will be incorporated.

The film 22 serves as a stock material onto which microwave interactive layer 24 is deposited to form microwave interactive film 26 consisting of film 22 and layer 24. Film 22 also separates a food product resting on top of laminate 10 from the microwave interactive layer 24 and the substrate layer 28. The film 22 must be sufficiently stable at high temperatures when laminated to substrate layer 28 so that it will not degrade during the operation of a microwave oven at temperatures selected for cooking the desired food. Suitable materials for use as a film layer include, but are not limited to, films such as polyesters, polyolefins, nylon, cellophane, polysulphone, biaxially oriented polyester and other relatively stable plastics. It has been found that biaxially oriented polyester is a preferred material for most food containers because of its heat stability and its surface smoothness.

The microwave interactive layer 24 is preferably deposited onto one side of film 22 by a vacuum vapor deposition technique. The side of film 22 onto which the microwave interactive material is deposited will face away from the food product in a container. Sputtering, printing or other techniques, which are known to those skilled in the art, may also be used to deposit a layer of lossy material which interacts with microwave energy onto one side of protective film 22.

Any suitable lossy substance that will generate heat in a microwave oven may be used as the microwave interactive material. These materials fall primarily into four groups: conductors, semiconductors, ferromagnetic materials and dielectric materials. Any of these materials which convert microwave radiation into heat energy may be used in the present invention. Preferred microwave interactive materials useful in the present invention to form microwave interactive layer 24 are those selected from the group aluminum, iron, nickel, copper, silver, carbon, stainless steel, nichrome, magnetite, zinc, tin, tungsten and titanium. These materials may be used in a powder, flake or fine particle form. The microwave interactive materials may be used alone or in combination with each other. The most preferred material for many applications of the present invention is aluminum metal.

The microwave interactive layer 24 is very thin. For instance, when aluminum is the microwave interactive material, it is virtually impossible to mechanically measure the exact thickness of microwave interactive layer 24 with presently known instruments. In general, the thickness of vacuum vapor deposited layers of electrically conductive material is measured in terms of the optical density of the conductive layer itself. Microwave interactive layers used in microwave cooking are so thin that after they are deposited on transparent film, the microwave interactive film made up of film 22 and microwave interactive layer 24 may be seen through by the human eye.

A wide variety of chemicals may be used to reduce or eliminate the heat-generating capability of microwave interactive layer 24. It has generally been found that aqueous solutions of chelating agents, solutions of Zr^{+4}, amines and hydroxyamines, dilute acids and bases and solutions of metal salts are useful in reducing or eliminating the microwave interactive properties of microwave interactive layer 24. Examples of chelating agents are ethylenediaminetetracetic acid (EDTA), diethylenetriaminepentacetic acid (DTPA) and hydroxyethylenediaminetriacetic acid (HOEDTA). Solutions of Zr^{+4} useful in the present invention may include ammonium zirconium carbonate, sodium zirconium lactate, ammonium zirconium lactate, and zirconium tartrate.

Examples of amines and hydroxyamines useful in the present invention include ethanolamines, choline and salts thereof. Acids useful in the present invention include acetic, formic, citric, tartaric, oxalic, succinic and other organic acids as well as dilute mineral acids, for example hydrochloric acid, hydrofluoric acid and mixtures thereof. Examples of dilute bases useful in the present invention include potassium hydroxide, sodium hydroxide, lithium hydroxide, sodium and potassium carbonates, and sodium and potassium phosphates. Solutions of salts such as ferric chloride, sodium citrate, sodium tartrate, ferric sulphate, ferrous chloride, ferrous ammonium sulphate, ammonium fluoride, sodium fluoride, zinc chloride, zinc oxide and zinc fluoride are examples of salt solutions useful in the present invention.

In general, sodium hydroxide is the preferred material used to treat microwave interactive layer 24 in accordance with the present invention, particularly when aluminum metal is the microwave interactive material making up the microwave interactive layer 24. The pH of solutions of sodium hydroxide used to inactivate portions of the microwave interactive layer 24 preferably ranges from about 7.5 to about 13 and is more preferably maintained in the range of about 8.5 to about 11. For a commercial process, the sodium hydroxide solution used to treat an aluminum microwave interactive layer is at room temperature although the temperature may be higher or lower than normal room temperature.

It is generally also adventageous to add a small amount of surfactant to solutions of an incativating chemical used to treat the microwave interactive layer to improve the wetting characteristics of the chemical and the subsequent reaction of the chemical with the microwave interactive layer. Examples of surfactants which may be used include CERFAK 1400^R produced by E.F. Houghton, KATAMUL-1G^R produced by Scher Chemicals, Inc., IGEPAL-CO630^R produced by GAF Corporation and TRITON X-100^R produced by Rohm & Haas. A surfactant preferred for use in conjunction with sodium hydroxide is TRITON X-100^R.

The mechanism by which chemicals modify treated portions of the microwave interactivate layer without removing the layer is not known for every possible combination of chemical and microwave interactive material. It is believed, however, that aluminum is inactivated by a variety of chemicals which oxidize aluminum metal. It is possible, however, that different chemicals will inactivate the microwave interactive layer by different mechanisms. Coordination, chelation, oxidation/reduction and/or formation of salts of the microwave interactive material may contribute to or cause inactivation of aluminum and other suitable lossy materials.

The substrate layer 28 may be made of a variety of materials but is preferably formed of a low density material having a relatively high electrical insulating capacity and a heat stability sufficient to withstand cooking temperatures in a microwave oven. Suitable substrate materials include, but are not limited to, paperboard, papers, plastics, plastic films, ceramics and a wide variety of composite materials such as fiber/polymer composites. A preferred material for use in disposable packages for prepared foods is paperboard.

A process, illustrated with reference to Figure 3, used to make microwave interactive laminates in accordance with the present invention, may be conducted by first providing a continuous roll of microwave interactive film 26 comprising film 22 and microwave interactive layer 24. As explained above, microwave interactive film 26 can be formed by depositing microwave interactive material in a layer onto one side of the film.

At treating station 30 the microwave interactive layer 24 (not shown in Figure 3) of the microwave interactive film 26 is treated with an inactivating chemical 38 by equipment illustrated by rollers 32, 34 and 36 which applies inactivating chemical 38, preferably as an aqueous solution or dispersion onto a selected area or areas of the microwave interactive layer. Inactivation chemical 38 interacts with the microwave interactive material of the selected area and converts the selected area into an inactivated area (14 in Figure 2). The inactivating chemical 38 reduces the capability of the selected area of the microwave interactive layer to generate heat in response to microwave energy.

Conventional printing techniques, for example rotogravure, flexography and lithography, may be used to treat the selected area of the microwave interactive layer with inactivating chemical 38. The printing techniques used may be conducted with equipment which is well known to those of ordinary skill in the art. Flexographic printing is preferred for many applications of the present invention.

After the inactivating chemical 38 has been printed onto the microwave interactive layer, the microwave interactive film is dried at drying station 40 with any conventional drier or driers, such as hot air driers, infrared heating driers, or steam heated rolls.The microwave interactive film 26 is dried after printing with chemicals 38 without removing the inactivating chemical or the inactivated material of the microwave interactive layer.

After drying, adhesive 51 is preferably applied to the treated microwave interactive film 26 at station 50 by equipment illustrated by rollers 52, 54. Alternatively, the adhesive 51 may be applied to substrate 56 rather than, or in addition to, the treated microwave interactive film 26. A variety of adhesives may be used to bond the microwave interactive film to the substrate. Adhesives found useful in the present invention include water based acrylic emulsions and casein neoprene emulsions.

After adhesive has been applied, the treated microwave interactive film 26 is continuously bonded to substrate 56 at station 60 by equipment illustrated by rollers 62, 64 and 66 to form microwave interactive laminate 10 of the present invention.

Preferably, only selected areas of the microwave interactive film 26 are inactivated by inactivating chemical 38, forming a shaped heating area, for example, activated area 12 illustrated in Figures 1 and 2.

The method of the present invention is further illustrated with the following example.

EXAMPLE

In this example, a selected area of an aluminum microwave interactive layer of a microwave interactive film was treated with a solution of sodium hydroxide (NaOH). The viscosity of a 1 normal NaOH solution was adjusted with a small quantity of neutralized ACRYSOL-A5, a polyacrylic acid solution produced by Rohm & Haas. A sufficient quantity of neutralized ACRYSOL-A5 was added to provide a viscosity of seconds on a number two Shell cup. After the viscosity of the NaOH solution was adjusted, approximately 0.3 grams of TRITONEX 100^{R} Surfactant were added per gallon of NaOH solution. Finally, isopropyl alcohol was added to the NaOH solution in an amount equivalent to about 7 % by weight of the NaOH and alcohol solution. A flexographic printing press was then used to print the sodium hydroxide solution onto selected areas of the aluminum microwave interactive layer. The amount of sodium hydroxide solution printed onto the selected areas of the aluminum microwave interactive layer was controlled by a 200 quad transfer roll. The treated microwave interactive film was then heated by contacting the microwave interactive laminate with the warm surface of a central impression drum of a printing press. An adhesive was then applied to a paperboard substrate and the microwave interactive film material was laminated (bonded) onto the paperboard substrate. The microwave interactive laminate formed as described above did not generate heat in response to microwave energy in a microwave oven and did not exhibit electrical conductivity.

Because the microwave interactive layer of laminates formed in accordance with the present invention generates heat only at the area or areas selected as the heating area or areas, the microwave interactive laminate does not have to be cut to the approximate shape of the food product prior to bonding to a package. This can lower package production time. Moreover, the control provided by the present invention over the shape of the heating area can be used to provide areas of heat-generating microwave interactive laminate where it is desired for a particular end use. In addition, overlap between heat-generating microwave interactive layers, which can occur when a package or container is assembled, can be avoided by inactivating selected areas of the microwave interactive layer that will overlap when the package or container is assembled.

A variety of improved packages or containers can incorporate microwave interactive laminates made in accordance with the present invention. With the present invention, for instance, pizza packages or pizza trays may be provided with a microwave interactive laminate having all areas of the microwave interactive layer of the laminate, which are not covered by the pizza, inactivated. This focuses the heat from the microwave interactive layer where it is needed to brown and crisp the pizza crust.

It is also sometimes desirable to provide pressed trays and plates which are not microwave interactive at the brim, sides or selected areas of the bottom of a tray or plate for performance or handling reasons. With the present invention, pressed trays and plates can be provided with a microwave interactive laminate in which inactivated areas of the microwave interactive layer correspond only to areas at which heating is not desired.

In addition, stripes of the microwave interactive layer may be inactivated to provide a grid pattern of alternating activated and inactivated areas. This grid pattern decreases the amount of heat that will be generated over the grid area as a whole.

Claims

1. A microwave interactive film in a microwave cooking heater element comprising a heat stable plastic film coated with a very thin layer of microwave interactive material to form said microwave interactive film, characterized by the presence in said very thin layer (24) of an inactivated area (14) wherein the capability of said inactivated area to generate heat in response to microwave energy has been reduced by treatment with an inactivating chemical in an amount sufficient to prevent said inactivated area from generating heat in response to microwave energy, followed by drying.

2. A microwave interactive film as defined in claim 1 wherein said microwave interactive material is selected from teh group consisting of iron, nickel, copper, silver, carbon, stainless steel, nichrome, magnetite, zinc, tin, tungsten, titanium and aluminum.

3. A microwave interactive film as defined in claim 1 or claim 2 wherein the inactivating chemical is selected from the group consisting of aqueous solutions of chelating agents, Zr^{+4}salts, amines and hydroxyamines, dilute bases and dilute acids, aqueous solutions of metal salts, and mixtures thereof.

4. A microwave interactive film as defined in claim 3 wherein said chelating agents are selected from the group consisting of ethylenediaminetetracetic acid, diethylenetriaminepentacetic acid and hydroxyethylenediaminetriacetic acid; wherein said Zr^{+4}salts are selected from the group consisting of ammonium zirconium carbonate, sodium zirconium lactate, ammonium zirconium lactate and zirconium tartrate; wherein said amines and hydroxyamines are selected from the group consisting of ethanolamine, diethanolamine, triethanolamine, choline and salts of the ethanolamines and choline; wherein said dilute bases are selected from the group consisting of potassium hydroxide, sodium hydroxide, lithium hydroxide, sodium and potassium carbonates and sodium and potassium phosphates; wherein said dilute acids are selected from the group consisting of acetic, formic, hydrochloric, hydrofluoric, citric, tartaric, oxalic and succinic acids and salts thereof; and wherein said metal salts are selected from the group consisting of ferric chloride, ferric sulphate, ferrous chloride, ferrous ammonium sulphate, ammonium fluoride, sodium fluoride, zinc chloride, zinc oxide and zinc fluoride.

5. A microwave interactive laminate comprising

(a) a microwave interactive film (26) as defined in any of claims 1 to 4 and

(b) a substrate layer (28) bonded to said microwave interactive film (26) to form a microwave interactive laminate (10), wherein said very thin layer (24) of microwave interactive material is between said heat stable plastic film (22) and said substrate layer.

6. A microwave interactive laminate as defined in claim 5 wherein said substrate layer (28) is selected from the group consisting of paperbord, papers and fiber/polymer composites.

7. A microwave interactive laminate as defined in claim 4 or claim 5 wherein said substrate layer is bonded to said microwave interactive film with an adhesive selected from the group consisting of water-based acrylic emulsions and casein neoprene emulsions.

8. A method for making a microwave interactive laminate of any of claims 5 to 7 having a substrate layer and a microwave interactive film comprising:

(a) depositing a very thin layer of microwave interactive material on one side of a heat stable plastic film;

(b) treating a selected area of said very thin layer with an inactivating chemical in an amount sufficient to convert said selected area into an inactivated area with reduced capability of generating heat in response to microwave energy; and

(c) bonding said microwave interactive film treated in accordance with step (b), to said substrate layer to place said very thin layer between said heat stable plastic film and said substrate layer.

9. A method as defined in claim 8 wherein said inactivating chemical is printed onto said very thin layer by a process selected from rotogravure, flexographic and lithographic techniques.

10. A method as defined in claim 9 wherein said inactivating chemical is printed onto said very thin layer with a flexographic printing technique.

11. A method defined in claim 10 wherein said microwave interactive film is bonded to said substrate layer in a continuous process in-line with said treating step (b).

12. A method as defined in any of claims 8 to 11 wherein said inactivating includes a surfactant.

13. A method as defined in claim 12 wherein said surfactant is selected from the group consisting of TRITON X-100^{R}, KATAMUL 1G^{R}, CERFAK 1400^{R}, and IGEPAL-CO630^{R}.

14. A container for the storage and microwave cooking of food, comprising:
a package having a surface or surfaces for enclosing and/or supporting a food product, and
a microwave interactive laminate (10) as defined in any of claims 5 to 7 bonded to said surface or surfaces to heat said food product in response to microwave energy.

15. A container as defined in claim 14 wherein said microwave interactive laminate (10) is bonded to interior vertical surfaces of said container.

16. A container as defined in claim 14 wherein said microwave interactive laminate (10) is bonded to a surface of said package which will support said food product.

17. A container as defined in claim 14 wherein said microwave interactive laminate (10) is bonded to a surface of said package which will be above said food product.

18. A container as defined in claim 14 wherein the inactivated areas (14) of the very thin layers (24) correspond to areas of said package wherein said very thin layers overlap when said package is assembled.

19. A container as defined in claim 14 wherein the heating area of the microwave interactive laminate is circular.

20. A container as defined in claim 14 wherein the heating area of the microwave interactive laminate is a grid of heating areas and inactivated areas.

Fig.1.

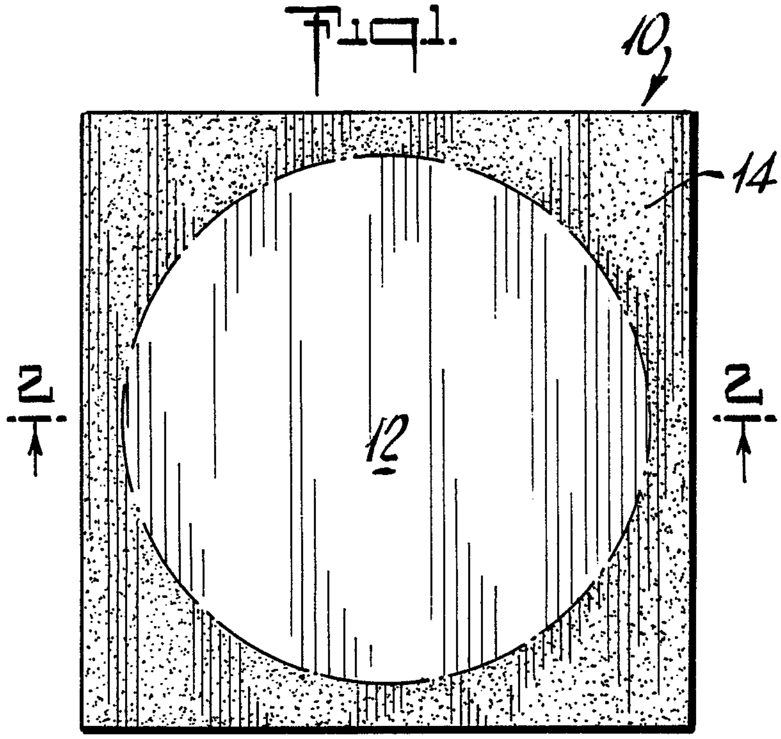
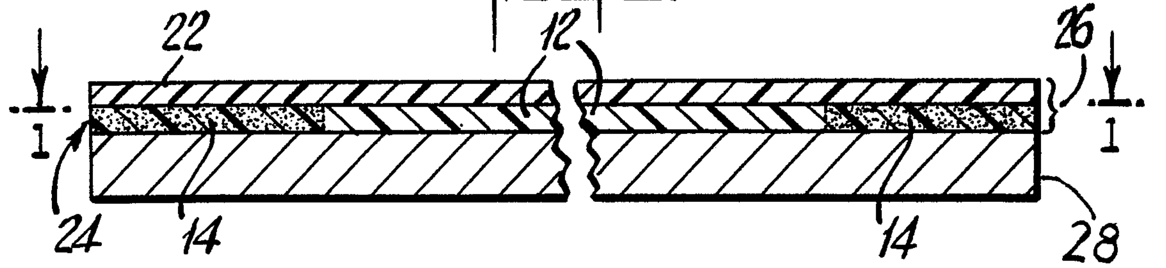


Fig.2.



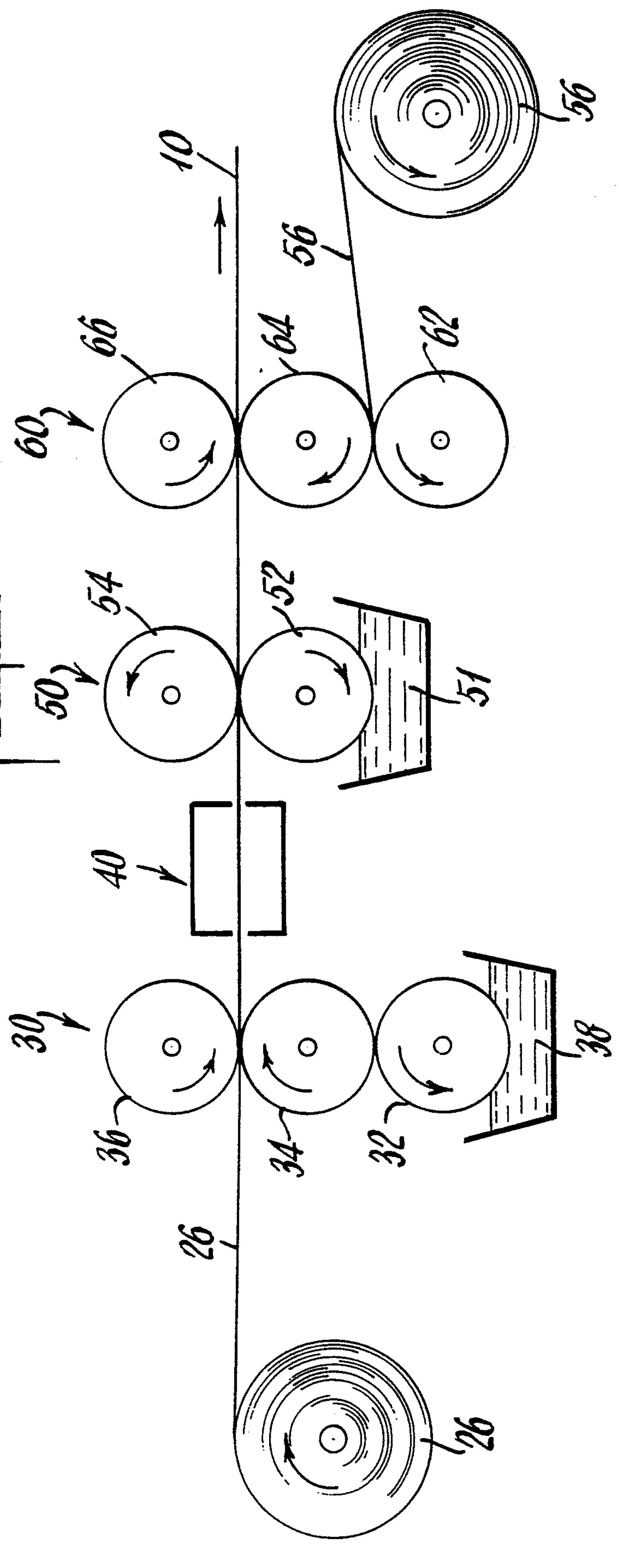


Fig. 3.